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ABSTRACT

The most common mode for the use of computers in education is for the student to be directed by the programed stimulus of the computer. This method has failed to solve the long-standing problems of education. The author suggests that the time-shared computer assisted instruction console should be used as a problem-solving tool for the student. He sees the computer as a tool for experimentation in new subject matters and as a simulator of unfamiliar environments. He finds the use of computers for drill and practice and tutorial projects to be inefficient. He discusses modifications that must be made in the mediation process if the student is to use the computer effectively. In the appendix several short papers discuss further uses for computers in education. A bibliography is appended. (JY)

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Introducing The Docile Technology Inmemoriam Of CAI

by Don D. Bushnell*

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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> "We're going to limp along in this country from one creaking innovation to the next on an incomparably, incompetent pathway to big brother norms and mice standard mediocrity until we take a divergent road in education. And that road is marked by an absence of competitiveness and compulsion . . . What we have to have are generous and unbuttoned classrooms and many, many styles of living and learning, without universal checkpoints to measure us . . ."
>
> Dan Pinck[1]

The general alarm that establishment education is not working with the slum child generally causes us to overlook the fact that it has not worked with many suburban white students either. The safe and sane technologies that have entered the educational market place over the last few years have been less than a match for those hallowed classroom traditions of our WASP ancestry:

(1) The tradition of authoritarianism dampens or destroys the student's innate drive toward learning and self-determination. The authoritarian posture of our educational system requires that student energies be directed at slavishly fulfilling tasks set by the system rather than by the students themselves.

(2) The tradition of passivity is extant in the schools. There is little requirement for the student to risk himself or to become even actively involved. Discipline is too often the principle and only concern of the instructor. Eventually the "undisciplined"

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leadership turns off and drops out.

(3) The tradition of "no controversy" in our schools - supporting the pretense that all life is good and simple and that controversy is somehow unwholesome - is current among educators. The great majority of schools will simply not recognize conflict and hence, in my opinion, fail to interest the student or prepare him for an honest encounter with the real world.

(4) The schools are word bound, little use is made of a physical or visual mode of learning.

(5) The inordinate dependency on competition as the one and only strategy for motivation stifles the innate joy of learning.

These are time honored conventions that sap the strength from most educational innovations. Much of the new electronic technology that has been readied for use in the classroom merely furthers these traditions, and unless we unbutton our thinking, computer assisted instruction (CAI) as currently applied will be no exception.

During the sixties, computer technology has reached a high level of acceptance into the educational system, both at the universities and in the public schools. With the marriage of the teaching machine and the flexible and "inhumanly patient" digital computer, CAI was given birth. The offspring inevitably caught the eye of the innovators who were beginning to despair of programmed instruction as the panacea for all educational ills. Numerous magazines, including the in-house American Education at HEW, saw CAI as a teacher surrogate. The CAI system will reportedly "never get tired . .

allow the individual to proceed at his own pace . . . make possible a daily tracking system in which a youngster moves up or down each day after each lesson . . . ensure the acquisition of basic skills for children of educationally deprived backgrounds . . . and provide a complete, instantly available record of each child's achievement and furnish information for course modification."[2] With this siren song offered up by the U. S. Office of Education, it is not surprising that many big city schools sought to tap into federal funds, and placate restless natives by bringing the most modern of all technologies into their classrooms. The history of these past applications has been chronicled for all to see.[3]

My quarrel with CAI, documented in subsequent pages, is not basically with factors of economics, standardization, or the lack of compilers and appropriate CAI languages, or even the paucity of curriculum, but with the simple fact that CAI perpetuates those traditions of education that have brought us to the present policy of brinkmanship that can lead only to disaster.

Consider the tradition of passivity for a moment. CAI, as it now stands, perpetuates this custom from a time when children were seen and not heard. If the learner's own interests and talents are stifled by machine-directed learning or the imposed demands of the system, the results may be facts temporarily stored, but at the cost of knowledge becoming irrelevant and curiosity being destroyed. The role of the teacher or teaching machine is to establish a balance between (1) a structured program and (2) the individual

student's innate desire to explore areas of his own interest. As a rule of thumb, it is perhaps better to offer opportunities or resources that the student cares about than the particular body of information that the teacher happens to know. At the very least, and no matter the discipline, if a student is allowed to ask questions that matter to him, he soon learns the habit of self-generating inquiry. Certainly active involvement or a willingness to risk himself in the process of change can't be expected in a system that is busy inculcating passivity and compliance.

The use of CAI in most applied programs could be characterized as machine-directed learning. The system dispenses instruction in a fixed, pre-programmed sequence of graded instructional material. Control of the instructional process lies with the machine and not with the student. The programmer-author develops an explicit a-priori model of instructional needs for all hypothetical learners and attempts to program instructional sequences that are tailored to these various needs. In fact, not enough is known about the human learning process to prescribe a specific model for organizing or programming a number of alternative learning experiences; therefore, CAI has had to proceed on a trial and error basis. Unfortunately, the programmer-author almost exclusively uses answers to multiple choice questions as his criteria for instructional sequences that work or don't work. Rarely is the student asked directly why he made an error or what particular misconceptions he might be

laboring under. Horn[4] raised the question of what errors in instructional programming can be discovered be diagnostic or criterion testing alone. He concludes that twenty-four of twenty-seven listed kinds of errors are not easily discovered through testing, and recommends interview of individual learners as a supplemental technique in materials development.

Contrasted with the CAI form of machine-directivity is machine-docility: a docile teaching system (under computer or human control) will perform operations only on the basis of student requests. It gives rapid and responsive acquiescence to the wishes of the learner. In this learner-directed mode of operation, the computer becomes the key to information retrieval from a vast knowledge bank of resource materials, or the students could apply themselves to a variety of complex projects in an ever widening range of disciplines. In the process, they could gain an understanding of the nature of problem solving and the variety of approaches open to solutions.

Some practical applications of machine-docility can be found in the work of Kemeny at Dartmouth, Jesse Richardson in Massachusetts, and Glen Culler at the University of California at Santa Barbara. In each instance, the computer's function is that of a rapid calculator letting the student "do his own thing." Here the machine is docile, not the student. And when the technology is used appropriately and uniquely for its particular capabilities, the student can study subject matters heretofore beyond his reach.

Inmemorium Of CAI

The thesis of this paper is that projects and programs involving instructional technology must place the learner in a key position of high involvement and self-directedness. To "turn on" the disenchanted, we need to engage him as an active participant in the real world: in the sciences, the arts, the community, the outdoor world, business and industry. By giving him the tools to become involved - i.e., the technology of the trades - we can succeed where other methodologies have failed: any functional system which allows for or actively solicits "hands on" experience will give the learner a sense of "oweness" that most educational experiences lack. Combining newly learned skills with the tools of the modern world gives an immediate opportunity to put these skills into practice. This fact, plus the promise of large rewards, makes learning relevant and exciting, and entrusts the learning to the student himself. This is what instructional technology should be all about, from the motion picture camera to the digital computer.

The history of technology in education is a history of great expectations and student disappointments. Where the technology has been placed in the hands of the learner - in the machine shop or the open computer shop - the promise has been fulfilled. Where it has been "screwed to the floor or locked in a booth"[5] the student has not had the opportunity to become engaged. The older generation is inclined to think of instructional hardware as a means for dispensing <u>their</u> information which is in turn to be digested by

students. Students, on the other hand, recognize the hardware for what it is - a part of the new information environment of electronically processed data and experience. Take the technology away from the student and he will have lost one of the best means for involvement and for relating "the educational scene to the mythic world of electronics and circuitry", to use McLuhan's words.[6]

Is the technology used to create an environment of involvement? This should be the first step in the evaluation of a CAI program. Involvement here is not defined as simply pressing typewriter keys in response to a controlled stimulus. Involvement with a central computer should require learning a simplified I/O language, probably an on-line mathematical language directed toward problem solving or mathematical analysis. The student should then be required to prepare a computer program to solve a simple mathematical problem. At the end of this short indoctrination, the student is ready to tackle problems appropriate to his course work. He is also free to use the computer for independent projects of any sort or even for his own entertainment. This kind of involvement helps the student gain a realistic assessment and attitutde toward cybernetic systems. Direct participation in the technology is a means of conquering the fear that the student might have when confronting new forms of electronic education. Once the barriers are broken down, and the student is sufficiently skilled to directly approach a subject area using the technology as a tool, the "turn on" between student and machine is a matter of course.

How does CAI stack up against the criteria of involvement? To answer this question adequately, I should like to distinguish among three different aspects of CAI systems paraphrasing a statement made by Ed Adams - Research Director of CAI at IBM - at a recent Project ARISTOTLE Symposium.[7] He refers to (1) content, (2) structure, and (3) mediation. Dr. Adams defines content as the corpus of information in a course; structure refers to the problems of sequencing learning experiences, or the strategy of building a complex of basic skills; mediation involves the process of communication with the student, the hardware system, the programming language the media forms, and human factoring of the interface between student and machine. Dr. Adams contends that a successful CAI program must succeed in each of these three aspects, stressing the point, however, that if the learning program is to be deemed successful as CAI, "the computer's function should be essential to realize some important instructional value." In other words, if you can fulfill the computer's function in any other fashion, then the computer should probably not be a part of the system: its role can probably be taken over by some less expensive form of technology, if technology is really needed.

Content Mediated By CAI Systems: Publishers And Sponsored Research

A major obstacle to the implementation of even the most rudimentary forms of CAI has been the lack of curriculum material appropriate

to the power of the mediating system. The public schools rely heavily upon the educational publishers and the manufacturers of multi-media instructional materials to produce the bulk of software packages. The educational publisher, on the other hand, looks at his market place with an eye to sales and can be counted on to prepare subject matters that are simply an adjunct to traditional classroom practices. Furthermore, textbook publishers employ few people who are skilled in automated communications systems: they end up producing lessons for CAI that are more appropriate to book form.

There are some lesson designers who use existing CAI systems to prepare and test new course material and find themselves locked into formats that frequently are not right for the subject matter under development.[8] Because of the particular configurations of most CAI systems, either experimental or commercial, these authors must necessarily avoid untried techniques and depend almost exclusively on programmed instruction formats. These researchers/authors fail to utilize the computer's unique potential in executing their curriculum programs. For this reason, and those given above, it is recommended that PROJECTS AIMED AT THE DEVELOPMENT OF CAI MATERIALS SHOULD BE INITIATED FOR THE EXPLICIT PURPOSE OF EXPLOITING THE COMPUTATIONAL OR SIMULATION POWERS OF THE COMPUTER FOR COMPUTER-MEDIATED LEARNING EXPERIENCES, THAT IS, EXPERIENCES WHICH A PRINTED, LINEAR TEXT COULD NOT OFFER, OR ANY OTHER MEDIA SYSTEM COULD PURVEY.

It has been suggested by computer manufactuers that the computer industry itself will supply curriculum materials. With the possible

exception of RCA, this suggestion has not borne much fruit. IBM, which bought Science Research Associates, Incorporated in 1964, has had a recognized capability in this direction, but has not yet demonstrated its abilities to produce. When IBM introduced the 1500 CAI System, they announced:

> "Preliminary versions of course materials that educators may use with the new instructional system are being developed by Science Research Associates, Incorporated, an IBM subsidiary. Course materials are in algebra, computer science, German, and statistics. SRA is also developing supplementary materials that allow the student to use the system to solve problems and perform simulated experiments in the study of physics, chemistry, biology, general sciences, and the social sciences."[9]

To date, SRA has not produced any CAI courses and the future is clouded as to whether they will even retain their exclusive status as IBM's purveyor of instructional materials. RCA, on the other hand, does show some promise of producing through Random House and Harcourt, Brace and World supplementary materials for use with existing curriculum packages. The problem that some industry people seem to be having with publishers is that the publisher recognizes that if they enter the market place at this early juncture married to a particular system, they may be limiting their future sales.

Another strategy - that teachers produce their own CAI materials - has received much greater support from those districts actually placing CAI on line for student instruction. The Brooks Foundation made the following recommendation to the School District of Philadelphia as part of its findings after a year's system study:

"A serious lack of instructional materials is the major problem facing a school district that plans to implement an individualized education program. The administration of the School District of Philadelphia will need to recognize this lack, and to tap resources in many parts of the country. In this regard, recommendations have been made for the establishment of a central library of computer-ready instructional programs in the District.

". . . Even with the establishment of a central library for its use the District will have to develop and validate instruction resources of its own. Recognizing the immensity of the programming task required for the introduction of CAI systems into the School District, the District must start to train instructional programmers. Because the skills required for instructional programming are difficult to identify and to impart, it should be expected that only three out of ten teachers will develop into good programmers.

". . . But the involvement of experienced teachers in the materials production program has major advantages:

(1) Teachers who have become programmers are more likely to accept and utilize the CAI system when it is introduced into their school.

(2) Years of experience with many approaches to conventional instruction will help teachers generate the numerous alternative approaches to the subject matter that are needed in an individualized program of study.

(3) A certain face validity for the material is gained where teachers know that other experienced educators have had a hand in its production."[10]

In looking back at this recommendation of some two years ago, it seems now that the Foundation was naive in assuming that the teachers could produce anything approaching the variety of experiences needed to truly adapt to the styles of learning of the individual student. They also suffer from the same unfamiliarity with the potential or power of automated instructional systems that commercial textbook publishers have in the past.

Summary

As long as CAI materials are limited to modes of instruction characterized by machine-directivity, they will not bring about the student involvement that is so desperately needed in the "buttoned-up"classroom. RATHER, THE TIME-SHARED CAI CONSOLE SHOULD BE USED AS A PROBLEM-SOLVING TOOL FOR THE STUDENT. This advantage, limited as it may now seem, will eventually enable the learner to undertake subject matters heretofore considered impossible in the classroom. Subjects that had been taught only at the college and university level could be approached in the secondary schools. For example, the launching and control of satellites, the study of the chemistry of genetics, the modelling of voter behavior, the analysis of creative writing styles, the composition of electronic music, the engagement in bargaining games - all become possible with the time-shared console. Systems are being designed so that students have direct access to primary sources of knowledge. From here it is not a big step to training in information management and decision-making, or for recognizing patterns in a vast data base. THE COMPUTER BECOMES THE IDEAL TOOL FOR EXPERIMENTATION IN NEW SUBJECT MATTER, AND FOR GIVING THE STUDENT AN EARLY EXPERIENCE WITH THE TOOLS THAT CAN INVOLVE HIM DIRECTLY IN A FUTURE WORLD OF ELECTRONICALLY PROCESSED INFORMATION AND DATA.

Computer Sequenced Learning Experiences

Using Ed Adams statement, "clear identification of the computer

added value should be the first step in evaluation of a CAI program"[11] the matter of structuring or sequencing learning experiences by computer takes on a new focus. In the halycon era of CAI, it was rather glibly claimed by this author that "responsiveness to student learning behavior can be achieved by branching the student forward, laterally, or backward through subject materials . . . for the following reasons:

> "(1) Characteristics of student response - the promptness and/or definitiveness of his reply.
>
> "(2) Nature of response - was it right or wrong, what specific errors were committed by the student?
>
> "(3) History of student learning behavior - his previous response pattern, peoblem areas, and reading rate.
>
> "(4) Relevant student personel data - his IQ, sex, personality, aptitude.
>
> "(5) Nature of subject matter.
>
> "(6) Degree of student motivation.
>
> "(7) Student-generated requests for rerouting."[12]

Certainly, if all of these factors were to be considered in determining the particular sequence of instructional materials for a given student at a given moment, the computer added value to CAI programs would be obvious. The computer is the only system that can carry out this kind of bookkeeping activity and monitor many students at the same time. But the question must be raised: how do the above listed criteria specifically affect the structure or sequence of learning experiences? The state of the science of learning being what it is, educational researchers have not devised a satisfactory strategy for the practitioners to lay hold of. The tool is willing, so to speak, but the body of knowledge is weak.

The programming of learning experiences can depend on "expert opinion" as it has in the past, or upon a theoretical structure based upon empirical research. Some would argue, as Karl Zinn does, "that the research tool must exist first before empirical data can be collected." But the research can't be conducted unless the significant variables are already known. Fortunately, a number of issues are already emerging from the research on programmed instruction. They all have some bearing on the factors relating to sequencing.

The three most general categories of variables are: "(1) content variables, arising from the structure of knowledge or the nature of the world; (2) instruction variables, arising from the method of instruction or the behavior of the instructor; and (3) inquiry variable arising from the behavior and characteristics of the learner."[13] These three variables, suggested by I. A. Richards, are not new by any means, but they will become more explicit and differentiated as the learning process is objectified so that it will be mediable by computer.

[14] "Content variables. These involve differences among familiar areas such as reading, mathematics, spelling, or music, or across such relatively unfamiliar categories as semantic, symbolic, figural (space, time, motion), and behavioral (social). I. A. Richards, for example, proposes a computer-based method for teaching reading and typing simultaneously to backward or underprivileged pupils, or to first graders or even pre-schoolers. The development of programs for such instruction is bringing to light certain interdependencies between literal notation (alphabetics or phonics), syntax, and meaning that are intrinsic to the subject of reading instruction. Richards recommends an approach that appears to combine the advantages of pure phonics and the word-gestalt methods while avoiding the outstanding disadvantages of both, such as rote drill in phonics and excessive redundancy in the word-gestalt method. While the objectives of this research

may be to produce better methods of instruction, immediate rewards are forthcoming in a better understanding of the structure of knowledge itself in a particular area whose importance can hardly be overstated.

"Instruction variables. These include sequence or order effects, size of units or steps, nature of reinforcement (positive or negative, simple or complex, intrinsic or extrinsic), frequency or regularity of extrinsic reinforcement, the whole area of teacher characteristics, and many other aspects of instruction that are relatively familiar. Not so familiar are instruction variables arising from the presence of the computer in the role of the teacher. The degree of program docility, as mentioned earlier, is a variable representing the degree to which the learner can direct the learning process, even into channels that the average teacher might reject as irrelevant or at least unscheduled.

"A whole family of instruction variables will have to be isolated in the effort to realize the computer's potential for on-line or short-lag modification of instruction to suit the needs of the learner. Essentially, this means that learners will encounter difficulties that are to varying degrees unexpected; the difficulties may be unique, rare, infrequent, or common. Common difficulties will be anticipated by branching sequences in instructional programs.

"A method of instructional materials development referred to as iterative (cyclical) tutorial revision promises to provide a data bank or library of common problems experienced by students in learning with textual materials. This methodology is the result of two years of experimentation in a slum high school in North Philadelphia by the Brooks Foundation.[15] Tables of frequency of occurrence of these problems have been constructed, and the more frequent problems could be anticipated in automated programs. Infrequent problems would require the intervention of a human teacher who was monitoring the learning process or who called in to help by the computer program itself when unanticipated responses were given by the learner. The teacher might then request from the data bank a list of alternate instructional tactics and select one or more for presentation to the student. Rare or unique difficulties would signify either a special disqualifying characteristic on the part of the learner or, alternatively, a conceptual approach to the material completely overlooked by the instructional programmers and curriculum developers. The discovery of such an omission would be a significant and valuable event and would call for a curriculum

conference including the most expert personnel; it has even been suggested that the instructional computer center might have "hot lines" to various university resources around the country who would be called in automatically to contribute to the solution of rare problems.

"Learner variables. The familiar concerns with aptitude, achievement, and interests are not diminished in our search for significant variables related to automated sequencing, but they will be supplemented by growing attention to new kinds of variables.

"It seems likely that the measurement of temperamental variables must develop rapidly, as the ease of massive complex data analysis begins to show important relationships with instructional variables. Such relationships have been very elusive in the past, but some investigators believe that they are both real and important in the educational process. The question, for example, of whether a student's preferred style of learning, active or passive, is dependent on inherited components of temperament, on learning during infancy or the pre-school years, or on learning during early school years has vast implications for instruction. For the educator, the essential question is: what can we change through instruction, and what are the givens, to which instruction must be adapted? The successful individualization of instruction depends heavily on the answers to such questions.

"In general, and especially among special school populations, such as the disadvantaged, the use of non-behavioral variables is important. Family background, neighborhood conditions, information in social agencies, from police to welfare, all have great potential value for research, both evaluative and theoretical, and for administrative planning.

"The study of motivational variables and blockage of learning is important for individual adjustment of instructional items and in studies of special populations that may have attitudinal or emotional handicaps . . . Computer assisted instruction programs can be alerted likewise, so that teacher help can be requested immediately when signs of behavior disorganization appear, or when students thought to have emotional or motivational problems are being machine-instructed. Special programs can be devised to hold attention and minimize threat in the instruction of these disadvantaged students."

Summary

The early promise of CAI was that it would give the learner rapid access to a body of information organized to his particular style of learning. Somehow we lost the way, probably due more to the paucity of programming strategies - based on a rigid, linear, step-by-step model - than to any other single cause. A PRIME NEED FOR ADVANCING THE STATE OF THE ART FOR CAI IS TO DEVELOP PROGRAMMING STRATEGIES THAT PERMIT THE LEARNER TO EXPLORE AND MANIPULATE A CORPUS OF INFORMATION IN A MANNER OF HIS OWN CHOOSING WHILE SIMULTANEOUSLY GIVING FEEDBACK THAT INCREASINGLY DEVELOPS THE STUDENT'S POWER TO SEARCH AND TO LEARN ON HIS OWN.

There is a clear need to continue the process of research into the variables that relate to the organization of a body of knowledge for easy access and productive learning; content, instructional methods, and inquiry practices should constitute a challenge for quite some time.

Communication Between Student And Machine - The Mediation Process

Applied CAI, as already emphasized, primarily is an automated means of dispensing information in the drill and practice mode of instruction. Students type answers to a string of spelling or word lists or select multiple choice answers to math problems in a paced presentation. The computer matches these responses with a string of correct answers stored in its memory. The pedagogical model here is the standard teacher operation of test and retest in a fully programmed

atmosphere in which all conditions of the stimulus and response cycle are anticipated (or thought to have been anticipated) by the programmer or instructor.

As David Stansfield states in a recent article in Educational Technology, "the chief weakness of any type of automated instruction is that it cannot cater to unanticipated responses from the student. If the student, quite reasonably, responds to the question, "What do cars run on?" with the word "roads" or "wheels" or even "faith" or "credit" (instead of "petroleum") or whatever it is, all the computer will be able to say is "Your answer is wrong, try again."[16]

The computer could be programmed with every possible response the student might be anticipated to make, but this would use up memory in short order. The basic point here is that the drill and practice mode of instruction is not a good use of CAI's potential. Even if the arguments that bookkeeping and releasing the teacher for more appropriate functions are profferred, this outmoted form of pedagogy is not appropriate to a cybernetic system. Better the memory drum or the flash card. And, for all that, how is the teacher expected to use all the data generated by these drill and practice sessions when he hasn't the time or the skills to digest the data he has already for improving his classroom procedures? The teacher could justifiably resent picking up a mountain of data where the computer left off.

Zinn comments that if, in this mode, economic criteria are important, users of computer-based drill exercises should also consider alternative ways of achieving their objectives for student learning.

Skills might be acquired more efficiently through paper-and-pencil exercises, or more pleasantly through interaction with other students, or more efficiently as side benefits of more complicated problem solving tasks aided by the computer.[17]

Beyond drill and practice applications, tutorial interactions between computer and student are basically of a programmed instructional nature. That is, the programmer has devised a computer program which in turn controls a pre-determined sequence of instructional material. By adding a computer to a programmed instruction course, the programmer theoretically gains the advantages of allowing for (a) constructed responses by the students; (b) variable sequencing of instructional materials (tailoring the sequences to a variety of student needs); and (c) easily computed statistical information on how well the students are learning, how effective the instructional routines are as teaching tools, et cetera. We have already seen how difficult it is to put these advantages into practice. In reality, this CAI mode has little to recommend beyond its value as a teaching machine except perhaps the pinball effects of the simulated conversation between the student and the machine (see the language interaction in the appended illustrations).

Consideration of the mechanics of communication between learner and machine falls into two general areas: (1) the "interface" between student input and machine output and (2) the language of the communication. Of the two areas, interface problems are the most easily solved as they are basically of an engineering nature.

An almost universal practice with CAI systems is to tediously type out the content material and then to follow this presentation with a long multiple choice question that calls for a one digit response. Perhaps one of the reasons that use of the time-shared computer in a problem solving or inquiry mode is so successful is that the computer and student or mathematician are in constant interaction. The laborious process of typing out long linear sequences of words is circumvented by the use of abbreviated terms that cause complete cycles of computation to occur. Tedious typing is avoided, but more importantly, there is an opportunity for frequent give and take between the inquirer and machine that approaches genuine dialogue. So arresting is this dialogue that a recurring phenonmena among those who have a console in their office or study area is the "computer-bum syndrome." The intensity of interaction between student and machine causes some highly motivated learners to go without food and sleep while trying to resolve a particular analysis or debug a program. The interaction becomes everything and the basic needs are overcome by the responsive system.

The limitations of the alphanumerical typewriter as currently applied to common CAI systems is not the only engineering problem related to this mode of automated instruction. Educators attempting to match their instructional needs against the characteristics of a particular CAI system must analyze input/output capabilities of the system against the kinds of media to be used in the instruction and

the kinds of responses it may be necessary for the learner to make. Listings of some representative examples of both media and response problems can be found in James Rogers' article in the September issue of Datamation:[18]

"(1) Kinds of material to be displayed to the learner.

(a) Text: in teaching foreign languages, we may wish to display text including special alphabetic characters; in teaching mathematics, chemistry, and logic, we require special symbols, signs, subscripts, et cetera, for displaying equations, formulas and expressions.

(b) Audio: we may want to play back recordings of spoken messages in teaching communication skills, languages or basal reading; and recordings of instruments in teaching music appreciation.

(c) Graphics: we may wish to display maps in teaching history; motion pictures in engineering or science; still photographs in medicine or art; circuit diagrams in electricity; graphs in mathematics or statistics; engineering drawings in blueprint reading; cardiograms in medical diagnosis; and so forth.

"(2) Kinds of responses to be required of the learner.

The terminal behavior specifications (i.e., the teaching objectives of the course, stated in terms of observable changes in the learner's behavior) for courses in various subjects might include the following items:

(a) State the expression for the area under the curve.
(b) Translate the above sentence into Russian.
(c) Fill in the missing parts of the following table.
(d) Point to the antibodies in the microphotograph.
(e) Outline the temperate zone on the map.
(f) Complete the circuit diagram.
(g) Describe a relationship.
(h) Define a concept.
(i) Explain how something works.
(j) Summarize the speaker's remarks orally."

In addition to the problem of supplying special type fonts or requiring graphic input capabilities, the nature of a student's constructed response is limited by the constraints of the CAI language and/or the techniques available for handling the problem of meaning. As with the varying responses to the question "What do cars run on?" constructed sentences of any significant number or length can have an almost infinite variety of word combinations, and it is difficult to compare the student's response to that stored in the computer's memory. Far too many of the CAI languages that program authors are required to use do not even permit acceptance of misspelled words, incorrect punctuation, or key word synonyms.

Because CAI languages represent an entire subject matter in themselves, they will be given short shift here. Zinn[19] lists over twenty author-languages being used in CAI systems. Of these, all but the machine language programs fall into essentially three categories: (1) CAI author-languages; (2) compiler languages; and (3) interactive computing and display languages. The first category represents those languages that are usually identified with most CAI systems (coursewriter, dialog, planet) and are designed to facilitate the construction of linear sequences of instructional materials and the control and sequencing of instructional items for the student. The prime limitation of most of these languages are that they do not permit genuine interaction with the computer to solve problems. This capability for interactive computing and retrieval or to retrieve data is a prime prerequisite for the kind of computer aided learning which has been defined throughout

this paper as the only form of CAI worth its educational salt. CAI languages are designed to perpetuate the standard classroom procedures of student monitoring, teacher directivity, passive learning, and frequent testing. Conventional compilers and interactive computer languages on the other hand permit great flexibility in problem solving behavior, allow the learner to monitor his own program, and most importantly, make it possible for him to interact with the computer as a computing machine and as a rapid data retriever and symbol manipulator. In other words, the computer in the hands of the user who is conversant with the general purpose or even special purpose compiler languages, can use this most powerful of intellectual aids in a manner entirely appropriate to its limitations and its unique capabilities.

Summary

If a search were launched for the ideal interactive computer system applied to on-going learning activities, Kiewit Computation Center at Dartmouth would be well up in the running. As described by Tom Kurtz, Director of the Center,[20] the use of the computer in secondary and even elementary education follows the earlier pattern set at Dartmouth. After a relatively short indoctrination course in which the students learn BASIC, a simple compiler language, students as far down as the seventh grade level use the time-shared system in almost all their science and math courses. In some eighteen private and secondary schools the full-time availability of time-shared computing enhances most of the student's formal course work, even without major curriculum

changes. Reportedly on the Dartmouth campus itself, the ability to have access to an interactive computer system has brought about radical changes virtually in all courses that deal with quantitative data. In the sciences, in the study of social data and courses in design engineering, business school, and the physical sciences, both students and faculty learn to use the computer as a matter of course.

The only problem today is that this kind of interactive system application is being overshadowed in many ways by conventional forms of programmed CAI. It is probably true that CAI applications are more easily understood because they don't require any sophistication in mathematical processes, but because the educators lack the facility to learn anew, it doesn't mean that student can't be more flexible.

In the design of hardware systems for CAI, there has been much discussion of multiple media capacities of the terminal devices. We have seen that for some course work a graphic of CRT display is almost essential. But if a priority were to be established on the design of hardware systems for a large number of schools, those that permitted genuine interactive or problem solving usages through inexpen sive or economical ties to a few central computer systems would have to receive prime funding.

APPENDIX

Reduction Of Teacher's Bookkeeping Tasks

It has been pointed out that the teacher spends a third of his time in the classroom not teaching. He acts as host, clerk, librarian, coulselor, housekeeper, policeman, data processor, and test grader and analyzer. Such time-consuming paperwork can be automated: a few school districts and two research centers are exploring the automation of various aspects. In Bellingham, Washington, for example, teachers report attendance by using a data-phone. The automated classroom at the System Development Corporation makes it possible for the instructor to collect test data automatically by means of the individual keyboard units at each student's desk, which are used to answer study questions and test items, or the use of an optical scanner which reads both typed and handwritten data. Scores are fed back to the teacher with both group and individual analysis handled by a time-shared digital computer. This feedback is received through a print-out device connected to the computer or through a TV display in the classroom. Even the student in his individual study carrel or working at a computer-based typewriter station can get immediate feedback on his test scores as well as appropriate normative data showing how he relates to students of similar ability and placement in the program.

Unquestionably, one of the most time-consuming activities of teachers in secondary schools is that of grading written compositions. The instructor faced with a typical student load of 130 to 150 students, producing essays once a week, has time to do little more than scan a paper, assign a grade, and write an innocuous comment in the margin. A computer at the University of Connecticut has been programmed with the data required for the grading of content errors, leaving the teacher free to study the creative aspect of the essay. By researching the kind of information which can be automatically gleaned from written essays errors in spelling and punctuation solecisms, distinctive vocabulary, style, et cetera - combinations of data have been sought which have high correlation with the evaluation of competent human judges. Researchers on Project Essay Grade report to date that when the computer is used to make evaluations of essays on the basis of quantitative elements, a correlation with human judging can be achieved at a level significantly higher than that which could occur by chance. Investigators are currently working on the problem of machine response to what the student is writing about and his scheme of organization. A computer-stored thesaurus is used to make comparisons with the student's selection of words and phrases. For determination of a student's mode of organization, the detection of such key words as "first, then, at that point, finally" helps suggest chronological organization. Words such as "consequently, therefore, inevitably, result could indicate preoccupation with cause and effect. Such lists are currently being used to confirm grading through application to student's essays which have already been judged by skilled graders.

Physical And Psychological Needs Of Students In The Educational Facility

New computer-based simulation techniques should be of vital interest to those planning the educational facility.

At Indiana University, Purdue University and at the St.Louis Junior College District, simulation techniques are being used to forecast future building and staff requirements under varying academic conditions. Scheduling, staff, and space are interrelated, for the manner in which the schedule is constructed determines, in part, the need for classrooms and laboratories. The development of a computer operated program or model at Purdue demonstrates the ease and simplicity with which the computer can facilitate the making of repeated calculations, summarizations, and reports of facility requirements by years (or terms) for varying programs, course requirements, student enrollments, and types of facilities.

Facility planning conventionally places greater emphasis upon the physical functions of a school building and the physical requirements of its users than upon the users' psychological needs. In a meaningful educational program, the student must develop certain social skills, acquire favorable attitudes toward learning and must be able to experience the integration of a wide range of learning activities. A student's success in these areas depends to a large extent upon his relations to other students, to teachers, and to the physical plant itself. The psychological needs of the student can best be met when requirements are taken into account from the beginning in the design of schools.

Informal learning experiences can help reinforce the skills and attitudes mentioned above. Such informal activities as brief conversations between teachers and students in the hallways, perusal of an exhibit or bulletin board, a casual review of games or plays in rehearsal have been identified and built into computer models to insure that architectural design will help to promote the satisfaction of cognitive and psychological needs. At George Washington University the psychology of architecture is becoming a new sub-discipline in the planning of educational and industrial facilities. A primary concern is with the "mix" of people that can be produced by planning a variety of informal learning situations, and "nodes" (small areas where two or three people may meet), and "zones" (large areas or territories in which people congregate). The use of a computer is making it easier for the architect to consider the mix, routes, nodes and zones that will support the informal learning experiences. While it is clear that a relationship exists between architecture and psychological dispositions, the nature of a relationship and its effect upon learning is obscure. A study in terms appropriate to both architecture and

the social sciences is needed. The computer might be employed for simulation and exploration of relevant variables so that the design of the educational facility will augment the effectiveness of its formalized program.

Scheduling The Non-Graded Continuous Progress School Program

Given the premise that students in the educational facility will no longer be herded in permanent packages of twenty to thirty, but will instead move back and forth within a fluid, larger setting that allows for independent study, small group work of many types, and various larger class activities, the administration will be hard pressed to keep track of each youngster's progress, and at the same time to organize the overall program around topics or themes with relevance for everyone. Flexible scheduling techniques offer the solution to this problem. It is widely held among educators that the flexible schedule increases the possibilities of innovation many-fold and, of course, scheduling involves a great many parameters whose experimental manipulation is indispensable to the development of educational methodology.

Among possible scheduling variations are: even period exchange, period augmentation, sequence rotation, compressed or expanded rotation, variable period length, and combinations of these. Grouping practices may involve size of group, grouping for ability, and grouping for motivation. Sections may be scheduled horizontally or vertical Subjects may be integrated in various patterns. When carrying scheduling to the ultimate degree, each individual may have a unique schedule and, moreover, his schedule may respond to his progress, so that it is not only unique but variable.

Every element in the dynamic system of the school is affected by any change in any of these parameters. With full computer support, the school can engage in wholly new approaches with little drudgery and waste of resources.

The last three years have seen widespread tests of two families of computer programs for building master schedules: Robert Holz's General Academic Simulation Programs (GASP), first developed to schedule the Massachusetts Institute of Technology, and the Stanford School Scheduling System (SSSS or S^4) devised by Robert Oakland and others at Stanford University's School of Education. The two approaches that led to GASP and SSSS may be distinguished as heuristic versus algorithmic, or pragmatic versus theoretical. These distinctions are somewhat artificial and inaccurate, but they reflect the fact that GASP involves producing twenty to thirty successive master schedules, each improved by human judgments of the previous schedule; while SSSS generates schedules from a more complete set of mathematical proposition concerning the nature of the scheduling problem and requires only a few repetitions to achieve its final solution.

Scheduling The Non-Graded Continuous Progress School Program

Advantages and disadvantages exist on both sides in the present state of the art, though further development will undoubtedly reduce them to the vanishing point. It appears that the heuristic and algorithmic approaches will gradually converge, so that the former becomes more elegant, more related to theory and less costly, while the latter becomes more articulated, more flexible and more responsive to hard realities. The non-graded program of the educational facility may be the ultimate test.

Simulation And Gaming: New Tools For the Disadvantaged Learner

Simulation and gaming are evolving computer applications which can provide particularly relevant instructional approaches to disenchanted youth. The greatest problem with these students is motivation; they are discouraged or hostile, or they just do not see the immediate relevancy of public school education to the lives they expect to lead. Nevertheless, these young peolle have motives. They like the approval of their peers, they like to compete in situations where they can win, they like to succeed. They like to talk about and participate in things that seem relevant to their own lives. They like to be in a situation where discipline does not seem to come from outside or from older authorities or from members of social groups of whom they are suspicious.

In connection with this type of student, games offer the following benefits:

(1) They can include competition among teams or between individual player and computer to any desired degree, a condition that tends to increase interest to the point of enthusiasm.

(2) They are student-centered and do not involve direction by an authority figure who might be resented.

(3) The teacher acts as an ally of the student, helping him to play the game so as to have the best chance of winning, just as a football coach is primarily an aide to winning the game and secondarily an instructor.

(4) Approval is largely or wholly from teammates, who are peers.

(5) Discipline does not need to be enforced from outside in gaming situations. Discipline is self-imposed by having to play by the rules and the necessity for team cooperation.

(6) If appropriate, real rewards, such as money, may be given for success in playing.

(7) The games may present any problem area, from those of strictly intellectual or mechanical content to those involving inter-personal relations. A game called the Family Game has a great deal in common

with family counselling, and could have a therapeutic effect on students whose family relationships are disturbed to some degree, as indeed many may be expected to be.

(8) A great deal of factual knowledge can be learned while playing the game, as well as from the requirement to marshall one's facts before entering the fray.

The Sumerian Economic Game has been developed at the Board of Cooperative Educational Services in Yorktown, New York. A set of programs have been written to permit a student to experience directly the basic principles of primitive agrarian economy. An IBM 1050/7090 computer system simulates selected elements of the economic functioning of a Sumerian city/state of 3500 B.C.

Each student takes the role of the king of ancient Sumer. Through interaction with the typewriter computer system, he begins playing the game. The following print-out is a typical portion of the simulated game showing the typewriter print-outs and the student's responses:

Imagine that you have just been made King of Lagahs, a city/state of Sumer in our year 3500 B.C. Twice yearly your royal steward will report to you the economic condition of the kingdom. Guided by these reports, you will decide the use of your resources (symbolized by grain), trying to keep your population stable and well fed.

Initial economic report made to you, the new King of Lagash, by humble steward:

Total population:	500
Net harvest, bushels:	5,000
Total farm land, acres:	2,000
Land now under cultivation, acres:	500

You must now decide how to use your resources.

How many bushels of new grain do you want placed in storage?

STUDENT RESPONSE: 100

The quantity of food the people received last season was satisfactory.

Expected gross harvest (based on planting):	7,920
Disaster crop losses this season:	
Net harvest, bushels:	7,920
Initial inventory:	100

Removed from inventory: -100
Loss by spoilage: none
Disaster inventory losses this season: 1,000
Final inventory: 1,000

You must now decide how to use your resources.

In the storehouse there are 1,000 bushels of grain one period old. How many bushels of this grain do you want taken out?

STUDENT RESPONSE: 1,000

How many bushels of new grain do you want placed in storage?

STUDENT RESPONSE: 3

Entry error. Please review instructions and try again.

STUDENT RESPONSE: 2,500

In the Career Game, now being prepared for computer mediation and developed in the Department of Social Relations at John Hopkins University, teams of girls are given information about a fictitious but realistic girl of seventeen. The players must decide what her life goals shall be, indicating the relative importance to her of marriage, children, an occupation, personel development, and the family standard of living. They then must decide about specific opportunities to fulfill these goals: when and whom to marry, how soon to have a child, how many children, whether to get a job, what kind of job to try for, whether to get additional education, and so on. In making these decisions, the players get help from various resources, ranging from a table showing them how much time certain activities take to extensive information about training requirements, competition, and recompense for various occupations.

After each set of decisions, the plays get back results indicating how well the woman is doing at achieving her goals and introducing certain events (whose occurrence is based on statistical tables), such as the birth of a child or success or failure at getting a certain job. A game may include ten decision periods, which take the woman to age fifty.

Games devleoped at John Hopkins Iniversity, Western Behavioral Science Institute, Brooks Foundation, and the IBM Corporation, run the gamut from democracy games - legislative, designed to show the dependenc of a legislator's re-election upon his ability to satisfy the desires of his constituents - a family game, and games to impart specifics of scientific subject matter.

BIBLIOGRAPHY

1. Dan Pinck. As quoted in The Village Voice, Nat Heintoffs' column. December twenty-eighth, 1968.

2. Louis Hausman. The ABC's of CAI. American Education. U. S. Printing Office, Catalog Number FS 5.210:10050. November, 1967.

3. Notes and Working Papers Concerning the Administration of Programs Authorized Under Title III, ESEA 1965. Prepared for the Subcommittee on Education of the Committee on Labor and Public Welfare/United States Senate. U. S. Government Printing Office. April, 1967.

   Datamation. September, 1968, Volume 14, Number 9.

   PACE: Catalyst for Change. Report Number 6 of the Second National Study of PACE. November twenty-ninth, 1968.

   C. A. Riedesel and M. N. Suydam. Computer-Assisted Instruction: Implications for Teacher Education. The Arithmetic Teacher. January, 1967, Volume 14, Number 1, pages 24 - 29.

4. R. E. Horn. What Programming Erros Can Be Discovered by Student Testing? Programmed Instruction. 1964, 4 (2).

5. Anthony Schillaci. The Now Movie. Saturday Review. December twenty-eighth, 1968.

6. Marshall McLuhan. Understanding Media.

7. E. N. Adams. In Proceedings of the First Annual ARISTOTLE Symposium. December sixth and seventh, 1967, Washington, D. C. National Security Industrial Association, 1968.

8. James L. Rogers. Current Problems in CAI. Datamation. September, 1968, Volume 14, Number 9, pages 28 - 33.

9. International Business Machines Processing Division press release. March thirty-first, 1966, page 2.

10. Brooks Foundation. The Computer and Educational Progress in the School District of Philadelphia. 1967.

BIBLIOGRAPHY

(continued)

11. E. N. Adams. In Proceedings of the First Annual ARISTOTLE Symposium. December sixth and seventh, 1967, Washington, D. C. National Security Industrial Association, 1968.

12. Don D. Bushnell. The Computer as an Instructional Tool: A Summary. System Development Corporation, SP-1554. February thirteenth, 1964.

13. I. A. Richards. In The Computer in American Education, (Don D. Bushnell and Dwight Allen, Editors). John Wiley and Sons, 1967, pages xvii - xxvii.

14. Richard de Mille. In Notes and Working Papers Concerning the Administration of Programs Authorized Under Title III, ESEA, 1965. Prepared for the Subcommittee on Education of the Committee on Labor and Public Welfare/United States Senate. U. S. Government Printing Office. April, 1967, pages 356 - 359.

15. Brooks Foundation (under U. S. Office of Education contract). The Validation of Educational Systems Packages for Occupational Training of Depressed Area Students.

16. David Stansfield. The Computer and Education. Educational Technology. May thirtieth, 1968, Volume 8, Number 10, pages 3 - 8.

17. Karl L. Zinn. Instructional Uses of Interactive Computer Systems. Datamation. September, 1968, Volume 14, Number 9, pages 22 - 27.

18. James L. Rogers. Current Problems in CAI. Datamation. September, 1968, Volume 14, Number 9, pages 28 - 33.

19. Karl L. Zinn. Instructional Uses of Interactive Computer Systems. Datamation. September, 1968, Volume 14, Number 9, pages 22 - 27.

20. Thomas E. Kurtz. The T-Computer: Its Role in Education. In Proceedings of the First Annual ARISTOTLE Symposium. December sixth and seventh, 1968, Washington, D. C. National Security Industrial Association, 1968.